INTRODUCTION
MRI at ultra high field (UHF) requires individual Tx-coils for excitation of different body parts since the construction of one large body coil, similar to those at lower fields, is difficult. Moreover, at 7T B\textsubscript{i} is inhomogeneous as the RF-wave length within the object is smaller than the object extensions. The travelling wave concept [1] offers the potential to overcome some of these restrictions: In RF-coils the usable B\textsubscript{i} -field is restricted to dimensions and geometry of the RF-coil itself, except the RF-coil is considered as a RF-resonator which can also overcome this restriction [4]. Contrary to this, in the travelling wave concept the usable B\textsubscript{i} -field is restricted to the dimensions of the waveguide (RF-shield) only. While standard transmit coils at 7T excite rather small volumes, the MR travelling wave concept allows the excitation of larger volumes only depending on the length of the RF-shield. For an antenna with a frequency of 297.2 MHz the approximate wavelength is about 1m. Thus the RF-shield of the gradient coil (Fig. 1A) with a diameter of 64cm can be used as a waveguide. As our system has an extended gradient RF-shield with a length of 1.58m the travelling wave concept has the potential to work as a whole body coil. This study evaluates the use as an efficient body coil replacement in the future.

MATERIALS AND METHODS
All measurements were performed on a 7T Siemens whole body scanner with SC72 gradient coil System (Siemens, Erlangen, Germany). If enclosing only air, the RF-shield has a cut-off frequency of 275 MHz for the propagating TE11 (H11) mode, which is below the proton Larmor frequency at 7T. The bigger diameter of the RF-shield of the 7T Siemens whole body scanner in comparison to other 7T systems [1] is an advantage. Thus, the wave propagates through the whole RF-shield without damping but a reflection of approx. 20% caused by the end of the RF-shield if no match is provided. The cut-off frequency decreases if the relative permittivity inside the bore increases. A patch antenna (Fig. 4A) was designed and constructed (Fig. 4B) by using field simulation software [3]. The antenna has a total diameter of 44 cm and a patch diameter of 24 cm. This 2 port patch antenna generates a circular polarized B\textsubscript{i} -field to achieve high excitation efficiency. The complete MRI scanner-system was simulated after designing a CAD model to analyze the behavior of the transmitted field under different conditions e.g. different positions of the antenna (Fig. 1C). The simulations were evaluated by performing several experiments, in which the antenna was used for transmit and receive. In additional experiments, the antenna was only used to transmit RF-power while a 12-ch. phased array [2] primate Rx-coil (Fig. 2A) and an 8-Ch. phased array human head-coil were used for signal reception. To increase the directional characteristics of the patch antenna, additional tuning and matching capacitors were mounted to excite a 180° flip angle with lower transmit voltage to increase the RF-Energy limit in inside the RF-shield. (Fig. 3).

RESULTS
The field simulation software allowed optimizing the directivity of the designed patch antenna (Fig. 4A) inside the MRI system. (Fig. 3B) shows that the excitation by the designed patch antenna can achieve the same homogeneity as the (Fig 2A) Dual Helmholtz CP coil (Tx) shown in Fig. 3B. The 12-ch. phased array RF-coil (Rx) exhibited residual inhomogeneities. This designed patch antenna can still be used for signal reception, but the signal-to-noise (SNR) is rather low since B\textsubscript{i} -filling factor for the patch antenna is insufficient for small objects like a grapefruit (Fig. 3B). With this designed patch antenna as Tx and a phased array RF-coil for Rx the highest SNR could be achieved under travelling Wave conditions because the B\textsubscript{i} -filling factor for phased array RF-coil is much better. Different positions of the patch antenna were tested. Best results were achieved by positioning the antenna at the entrance of the RF-shield of the gradient coil (Fig. 1B). Using an extra-long RF-shield as a wave guide, the travelling wave excitation opens the potential to act as an efficient body coil under UHF conditions. However the remaining problems of exposing sensitive body parts, such as the human head by increased SAR needs to be solved [5].

CONCLUSION
To apply the travelling wave concept to act as an efficient body-coil some limitations need to be solved. The limited RF-power at standard 7T whole body MRI-Systems is 8 kW peak power in comparison to 25 kW peak power are required for an internal 3T body-coil. 7T RFPA are much more expensive instead of 3T RFPA. In the present state the travelling wave concept will be able to work as a body-coil at 7T for small objects such as primates.

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REFERENCES

Fig 1: A) Scheme of propagating waves inside RF-shield B) patch antenna for RF excitation on backside C) simulation model of the 7T MRI system [3]

Fig 2: A) Dual Helmholtz CP coil (Tx) and 12-ch. phased array coil (Rx), B) 8-Ch. phased array head-coil Rx only with passive detuning

Fig 3: A) MRI of an grapefruit acquired with Dual Helmholtz CP coil (Tx) and 12-ch. phased array coil (Rx) B) MRI of an grapefruit acquired with patch (Tx) and 12-ch. phased array coil Sequence Parameters: GRE with TR: 100ms, TE: 10ms, matrix: 256x256, slice thickness: 2.5mm, slice distance: 1mm, FoV: 155x155mm

Fig 4: Designed patch antenna A) Simulation model [3] B) front side of the constructed prototype C) back side of the constructed prototype